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COMPLETE SPECIFICATION

Method and Apparatus for the Production of Random Signal Sequences

We, C. LORENZ AKTIENGESELLSCHAFT, a German corporate body, of 42, Hellmuth-Hirth - Strasse, Stuttgart - Zuffenhausen, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to methods and apparatus for the production of random signal sequences.

In connection with statistics and for coding purposes, random sequences of letters and numerals are required to a constantly increasing extent.

These sequences have hitherto been produced in a very complicated and time-wasting manner, usually by hand. It is seldom possible to obtain a true random distribution by such methods, particularly by manual methods.

Methods have consequently been developed which produce random sequences of figures and letters and which are so simple and operate in such an easily supervised manner that, in practice, the randomness of the sequences obtained is assured, even in continuous service.

The invention provides a method of producing sequences of signals which are distributed at random and which consist of groups of signal-elements, the individual elements each having one of two criteria, comprising applying an operating condition intermittently to an oscillator, each application of the said condition giving rise to a series of impulses and the frequency of the oscillator and/or the time during which impulses are produced by the oscillator for each application of the said condition thereto varying in a random manner due to variable determining factors, so that the number of impulses in each series is random, wherein each series of impulses is applied to a bi-staple trigger circuit which oscillates from one to the other stable state due to the action of the individual impulses of the series and which, in dependence upon the number of impulses in the series, remains at the end of the series in one or other of the two stable states at random, a signal-element being produced at the end of the series which has one or other of the two criteria according to the stable state in which the trigger circuit remains and a number of signal-elements thus produced being combined to form a signal.

The two criteria may be positive and negative polarity.

In one method according to the invention, current is applied to the oscillator n times in succession in order to produce n elements which together form an n-element signal.

In an alternative method according to the invention, current is applied simultaneously to n oscillators having associated therewith n trigger circuits, each of which thus produces a signal element, the n elements produced together forming an n-element signal.

Signals produced by the methods referred to may be recorded, in any desired grouping, by electrical control means or they may be recorded in the form of perforations in teleprinter tape.

The invention also provides apparatus for carrying out the methods referred to.

One form of apparatus, and its method of operation, will be more fully described, by way of example, with reference to the accompanying drawing.

The complete circuit can be regarded as comprising two sections. Section 1 is an impulse generator or oscillator, that is an arrangement for generating short electrical impulses in a random manner. Section 2, which is a valve trigger circuit having two stable states, is operated by these impulses.

The operation of this apparatus will now be described in detail. Upon operating a key Ta, the control voltage U_{st} charges a condenser C_{L_1} and, through a resistance R_L, also a condenser C_{L_2}. When the voltage at the condenser C_{L_2} reaches the striking voltage of the relaxation oscillator valve I, the condenser C_{L_2} is discharged. The valve I generates voltage impulses for as long as the key Ta is closed and, after the key is opened, for as long as energy continues to flow from the condenser C_{L_1} to the condenser C_{L_2}.

If the key Ta is operated for a predeter-

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mined time t, that is, if current is applied to the oscillator 1 for a time t, the number of impulses generated by the valve I will depend upon the time t and also upon a large number of determining factors such as the capacities of the condensers C_{L_1}, C_{L_2} and C_K, the resistances R_A, R_L and R_K and, above all, all the momentary electrical working conditions of the valve I of the Kipp relaxation oscillator. These determining factors all vary to at least a small extent and, in consequence, when Ta is actuated repeatedly the number of the relaxation oscillation impulses generated during the time intervals for which the key Ta is closed is subject to random fluctuations even when the time t is constant. In addition, when the arrangement is operated in practice, the time intervals during which the key Ta is closed are not exactly equal to one another, even if the key Ta is actuated rhythmically. Moreover, if the control voltage U_{st} is taken from unstabilised mains, the mains voltage fluctuation causes the voltage U_{st} to vary so as to act as a further random determining factor. However, it has been shown by experiment that it is, in fact superfluous to make special provision for obtaining such voltage fluctuation since it does not provide any greater certainty that the sequences produced will be random. The random fluctuations of the other determining factors of the impulse generator are alone quite sufficient.

A valve II, which serves to amplify the voltage impulses, is connected to the relaxation oscillation valve I through a coupling condenser C_K and a coupling resistance R_K.

The bi-stable trigger circuit 2 consists of two valves III and IV. It is impulsed by the anode potential of the valve II. It is inherent in the circuit arrangement that one of the valves III and IV is always blocked by a negative grid biassing potential while the other is conductive. If an impulse occurs simultaneously on both grids, the blocked valve is opened by it and the valve which was previously conductive is blocked.

Consequently, if a series of impulses comprising an even number of impulses is transmitted to the trigger circuit upon actuating the key Ta, the trigger circuit returns to its initial condition at the occurrence of the last impulse, that is, at the end of the series. On the other hand, the last impulse of a series comprising an odd number of impulses leaves the trigger arrangement in the condition opposite to its initial condition.

The impulses generated by the impulse generator thus cause the trigger circuit to oscillate rapidly between its two stable states, finally remaining stable in the "odd" or "even" state according to the number of impulses which have been applied to it.

According to the state of the trigger circuit, the indicator relay R disposed in the anode circuit of the valves III and IV has its contact positioned on "positive" or "negative". Thus, if the key Ta is operated repeatedly by an automatic control arrangement, a random sequence of pulses or signal-elements each having one of the two criteria "positive" and "negative" is obtained.

This random sequence of positive and negative signal-elements is sub-divided to form groups of elements, each group forming a signal. For example, if operation is to be carried out with a five-unit code providing thirty-two different possible signal-groups, five consecutive impulses have to be combined to form a signal group. The signal-groups correspond to letters and/or numerals so that a sequence of letters and/or numerals, distributed at random, is obtained.

Now, in general, the oscillator needs to be impulsed n times for the n elements of an n-element code signal to be produced. This method is often too tedious, and it is desirable to arrange for the n elements of a code group to be obtained more rapidly. For this purpose n circuits similar to that shown in the drawing are used, each having its own oscillator and trigger circuit. If the inputs of the n oscillators are connected to a common voltage source U_{st} and to a common key Ta, then each time that the key Ta makes contact, each circuit produces one signal-element. The assembly of n circuits thus produces simultaneously from a single keying operation the n elements which are needed for one n element signal group.

Since the valve circuits have only a very low inertia, the operating speed is, in effect, limited only by the inertia of the indicating relay R. Even this limitation may be avoided by the use of an electronic rather than an electro-mechanical relay. Moreover, in cases in which it is not desired to obtain a permanent record of the signal-elements by mechanical means, an inertia-free indicator element such as a glow discharge tube or the like can be employed.

During tests, it was found possible to carry out up to 500 keying operations per second. This corresponds, in the five-unit code, to an output of 100 letters or figures per second.

As regards the technical execution and the method of operation of the device, it is immaterial whether ion tube trigger arrangements or suitable electron tube circuits are employed for generating the electrical impulses. Similarly, it does not affect the method of operation if the trigger device comprises two mutually blocking electron tubes or one or more ion tubes.

There are many uses for the sequences of letters and/or numerals derived by the method described hereinbefore. An important use is for encoding purposes in the communications field. To this end, a sequence of random letters and/or numerals can be recorded with any desired grouping of the signal-elements so that a code is formed which can be

employed for encoding information manually.

If automatic coders are to effect the encoding, the conversion of the groups of signal elements into letters and/or numerals can be dispensed with. Instead the signal-elements are recorded directly in the form of perforations in tape suitable for tele-printer operation, the tapes then being used to control the automatic coding equipment.

In addition, to coding purposes, the random signal sequences derived are also useful in other fields. For example, if the groups of signal-elements are recorded in the form of numerals, they can be employed as sequences of random values for statistical purposes.

What we claim is:—

1. A method of producing sequences of signals which are distributed at random and which consist of groups of signal-elements, the individual elements each having one of two criteria, comprising applying an operating condition intermittently to an oscillator, each application of the said condition giving rise to a series of impulses and the frequency of the oscillator and/or the time during which impulses are produced by the oscillator for each application of the said condition thereto varying in a random manner due to variable determining factors, so that the number of impulses in each series is random, wherein each series of impulses is applied to a bi-stable trigger circuit which oscillates from one to the other stable state due to the action of the individual impulses of the series and which, in dependence upon the number of impulses in the series, remains at the end of the series in one or other of the two stable states at random, a signal-element being produced at the end of the series which has one or other of the two criteria according to the stable state in which the trigger circuit remains and a number of signal-elements thus produced being combined to form a signal.

2. A method as claimed in claim 1, wherein the two criteria are positive and negative polarity.

3. A method as claimed in claim 1 or claim 2, wherein current is applied to the oscillator n times in succession in order to produce n elements which together form an n-element signal.

4. A method as claimed in claim 1 or claim 2, wherein current is applied simultaneously to n oscillators having associated therewith n trigger circuits, each of which thus produces a signal-element, the n elements produced together forming an n-element signal.

5. A method as claimed in any of the preceding claims, wherein the signals are recorded, in any desired grouping, by electrical control means.

6. A method as claimed in any of claims 1 to 4, wherein the signals are recorded in the form of perforations in teleprinter tape.

7. Apparatus for carrying out the method claimed in any one of the preceding claims.

8. A method of producing sequences of signals, substantially as herein described with reference to the accompanying drawing.

9. Apparatus for producing sequences of signals which are distributed at random, substantially as herein described and as shown in the accompanying drawing.

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1 SHEET

This drawing is a reproduction of the Original on a reduced scale.